

**ANALYSIS OF COMBINATION OF NON-TRADITIONAL HEATING AND VENTILATION EQUIPMENT IN LABORATORY CONDITIONS**

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*Received: 05 Nov. 2017**Accepted: 27 Nov. 2017***ANALYSIS OF COMBINATION OF NON-TRADITIONAL HEATING AND VENTILATION EQUIPMENT IN LABORATORY CONDITIONS****Miroslav Rimár**

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**Keywords:** ventilation, heat recovery, ANSYS, secondary heat gains

**Abstract:** Paper is dedicated to the issue of heating of the closed areas by using of a ventilation system with forced air supply and heat recovery and floor convectors with installed fans. Experiment and simulation model created in system ANSYS Fluent 14.0. In the simulation as addition were secondary gains included heat gains from the computers and monitors and heat gains produced by the service personal. The result of the experimental measurements as well as the realized simulation confirms the possibility of heating a room only with HRV as well as possibility of heating of it combination with floor convectors.

**1 Introduction**

Energy-efficient buildings are objects which meet all the legislative requirements; however, they are real effective only if they satisfy the requirement of a subjective thermal comfort. If this subjective condition is not met, there is a risk of the deployment of other alternative ways of heating or cooling. An example is the installation of additional equipment such as space heaters, and mobile air conditioning units that may have substantially lower efficiency than the already installed systems of heating, ventilation and air conditioning (HVAC). This way poorly designed systems which on the one hand meet all regulatory requirements, but on the other hand are not subjective comfortable after installing further equipment significantly disrupt the energy balance of the building.

Accurate measurement of thermal comfort is a very difficult task, because it's very subjective measurement. In General, thermal comfort depends on air temperature, humidity, radiant temperature, air speed, the metabolic processes of the individual human being, but also used clothes, on the basis of the subjective sense of man comfort or of Physiology [1-5]. According to the standard ANSI/ASHRAE 55-2010, thermal comfort is defined as "condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective

evaluation." People's satisfaction with temperature conditions is also assimilated with the comfort of humans and the thermal comfort is a factor should be reckoned with, while design the working environment or conditions of the individual properties and buildings.

The feeling of an individual comfort will be pleasant, when the body of human not overheating, but at the same time, in the case of active cooling are not felt locally decreases the temperature and air flow. An important aspect is the knowledge that, at the same time, the temperature of the skin is not identical at all areas of the body, according to the physiological point of view. Important aspect that affects the distribution of thermal comfort perception is the level of thermal insulation properties of the used clothing. A general idea for thermal comfort is a steady-state environment necessary to maintain a constant body temperature. So, it is necessary to achieve a thermal balance, in which the environment is taken from the human body as much heat as body produce.

The determining factors of the calculation and design of thermal comfort include:

- The rate of metabolism: the energy produced by the human body
- Insulating properties of clothing, the amount of thermal insulation in clothing man

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- Air temperature-ambient air temperature
- Radiant temperature-weighted average of all the temperatures of surrounding surfaces
- Air velocity-the rate of speed of the air movement
- The relative humidity

Environmental factors include temperature, radiant temperature, relative humidity and velocity of the air. Personal factors are the level of activity (metabolic rate) and clothing.

Thermal comfort is calculated as the energy balance between the heat transfer from radiation, convection and conduction which are balanced by metabolism. Heat transfer occurs between the outside environment and the human body with the average calculated area of 1.81 m<sup>2</sup>. If the heat transfers from the human to environment more than in the other direction, one sees it as a "cold". If the heat transfers from environment to the human more than in the other direction, one sees it as a "warm" or "hot" [6-10]. Literature [10] also defines the state of the thermal comfort as such when body does not feel heat or cold. From the foregoing, in order to create suitable conditions for the well-being of a person, it is necessary to ensure the required state of the environment. Among the particular factors affecting the thermal state of the environment in relation to the person are: (1) air temperature, (2) the temperature of the surrounding areas, (3) humidity, (4) air speed. The feeling perceived from any single part of the body will depend on the time of exposure, the place and the used clothing, as well as the ambient temperature.

**2 Materials and methods**

Experimental study was made in a laboratory of renewable energy, Department of process engineering at the Technical University in Košice, Slovakia. The plan of the laboratory is shown in Figure 1. Air exchange in the laboratory is provided with ventilation recuperation unit. Air injection and exhaust pipes are located at the ceiling of the room. Fresh air is supplied to the laboratory through the pipes 1 of rectangular cross section with the gradual reduction of the cross-sectional area of the pipe line to ensure the necessary dynamics of air flow. The exhaust air is going out through the pipes 2.

From Figure 1, it follows that the first air canals have two diffusers, while the second has three. Diffusers are placed in such way to be in front of the axis of the centre of each window. HRV heat recovery unit (Sabiana ENY 3) is located in the next room. Configuration of the HRV allows preheating of fresh air by using an integrated hot water exchanger or an integrated electric heater in the case when the temperature of the intake fresh air from outside is low and recovery process itself would not be enough to

raise the temperature to the desired value, in the winter period. System of regulation and control is guaranteed by the DESIGO program, Siemens, figure 2.

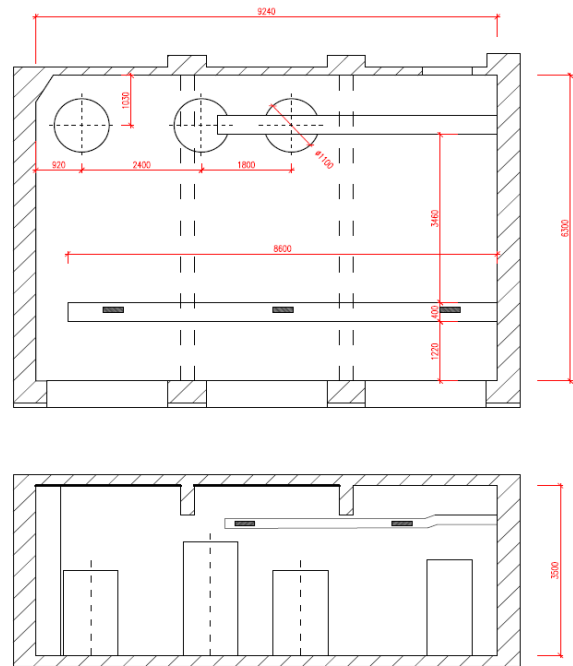


Figure 1 Laboratory of renewable energy sources.

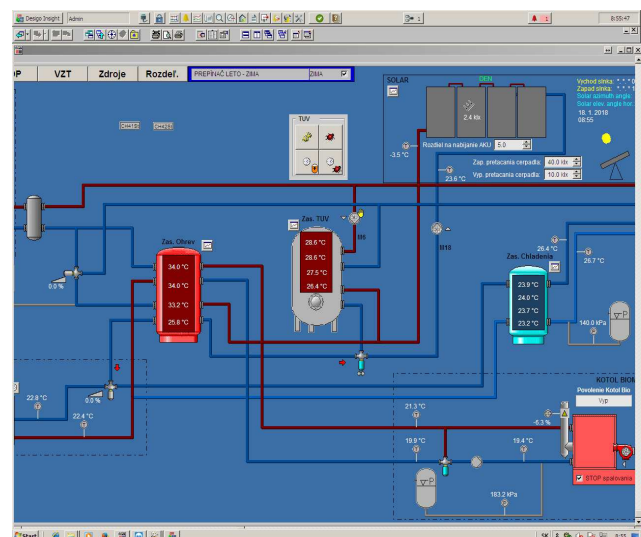


Figure 2 Visualization of the monitoring data.

The temperature in the lab according to EN 12831 should be 20 °C.

Thermal characteristics of the building elements, Windows, walls, floor and ceiling have been set according to their technical documentation.

- The thickness of the inner walls is 200 mm and the temperature is 22 °C.

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- The outer wall has a thickness of 500 mm and the average temperature of the of the wall is 18 °C.
- The Windows are plastic with double glazing, the surface temperature is 12 °C.
- The ceiling and floor have a thickness of 300 mm and a temperature of 22 °C.

The main sources of heat in the laboratory are floor convectors with axial-radial fans, which are installed in the line below the windows. The surface temperature of the heating elements in the heating period is 42-45 ° C. Control panel of the convectors allows you to regulate the performance by the three-gear system; fans can be operated also in passive mode. This mode allows you to take advantage of convectors as the conventional radiators. In the laboratory installed three storage tanks (Figure 1) for the solar system and the boiler for biomass. The heat losses form storage tanks represented as thermal gains to the laboratory. The tanks are insulated with mineral wool with a thickness of 100 mm. Surface temperature during the day, in the first tank (located at the corner of the room) is approximately 24.5 ° C, the second – 23,5 ° C, the third – 22 ° C. The average temperature of the water inside the containers is about 37.5 ° C in the first tank, 32 ° C in the second and 25 ° C in the third. The laboratory is also the workplace consisting of six tables with computers and monitors. Location of the computers is on the floor under the desk. Due to the fact that the PC workstation, have significantly higher consumption of energy, their thermal gains is around -100 W/m<sup>2</sup>. This parameter was included to the simulation model. Heat gains from the monitor are 50 W/m<sup>2</sup>.

3D model of the laboratory was created by using ANSYS design modeller, which provides a stable calculation and eliminates inaccuracies in the geometry, which can arise when importing from another CAD software. To achieve better quality of the calculation mesh has been selected ANSYS mesh solver. For calculation were used „proximity and curvature advanced size function with fine relevance centre, active assembly initial size seed, high smoothing and slow transition“. According to the settings model has 2 958 471 elements. A simulation model also includes simplified models of human bodies with average surface temperatures of 36 °C.

**3 Simulation**

A simulation model of the heating and ventilation has been created in the program of ANSYS Fluent 14.0. For complex simulation were selected models for energy calculation, flow calculation - K-epsilon model and radiation model p1. The air input was chosen as velocity inlet with the input speed of 0.2 m/s and medium

temperature 19 ° C. For the outlet was selected pressure outlet. All parameters were set according to the technical documentation of HRV and thermal comfort standards. Research of the parameters of heat recovery ENY 3 was not the purpose of the current work. Figure 3 illustrates the "streamlines" of fresh air flow and temperature contours of the laboratory.

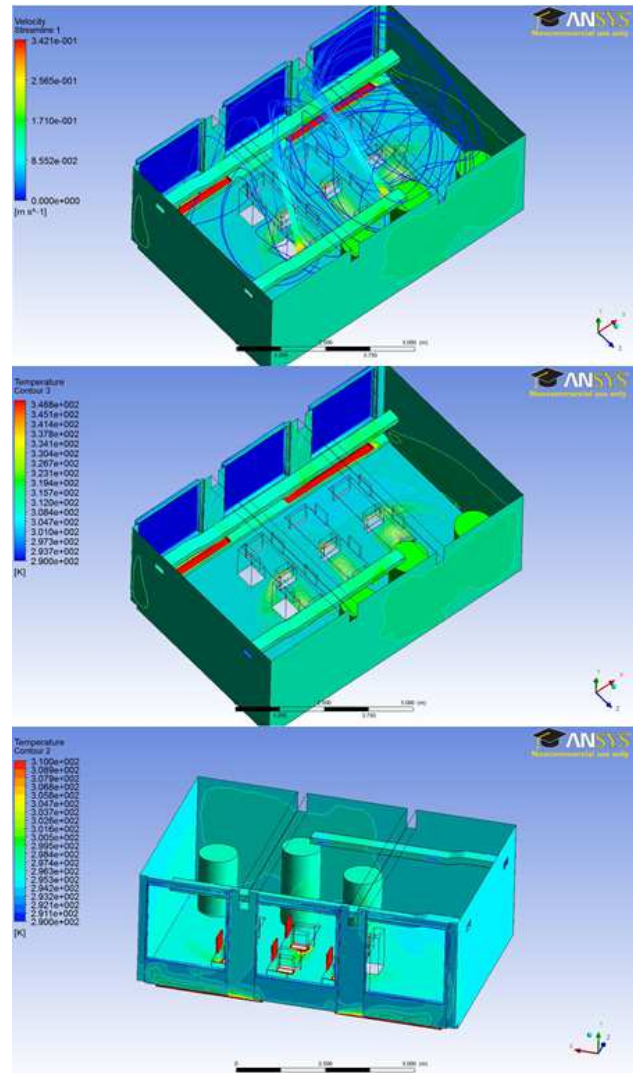


Figure 3 Simulation results

The shape of the canal (pipe) and air diffusers as well as the air speed causing turbulent flow of air masses in major part of the laboratory space. The maximum speed of the fresh air is 0.36 m/s, which is much lower than the max value provided at EN 12831.

The lower part of Figure 3 shows the heat flow and temperature on the surface of the walls, windows and floor. Entering fresh air acts as a thermal barrier between the



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windows and the rest area of the laboratory. This is possible due to the difference of the temperatures of the inlet air and the walls.

Fresh air, after entering give certain amount of heat to the exterior and drops to the floor surface, where convectors are located. After heating the air goes up, where it mixed with the original air and subsequently divided into two streams. The first stream is circulated with fresh air. The second is exhaust to the canal with the bad air. The air circulation in the laboratory is in terms of the dynamics of the streams is time-stable, and as result has relatively constant temperature of the mixture in each of the volume parts of the room.

The internal air temperature according to the measurements by the thermometers and installed heat sensors is 22 °C. According to the simulation temperature is 21.8 °C, which is 99% accuracy of the result. The difference between the results is affected by simplifying the heat transfer through the wall. Simulation of the wall heat transfer does not account with the parameters of thin layers, such as colour. The surface temperature of floor was lower versus the upper half of the laboratory only by 0.4 °C.

Also, was made simulation of the laboratory heating only with HRV (fig. 4). To do it, the temperature of the inlet air was increased to 22 ° C (the corresponding value according to EN 12831). It follows from the results of the simulation and figure 4, floor convectors have a significant effect on temperature and air flow masses in the laboratory.

The temperature change is visible in a vertical layout. The temperature of the floor layers is lower by 2 °C compared to the temperature in the upper part of the room. Reduction of the temperature has changed the air circulation in the room floor. The average internal temperature has remained unchanged of approx. 20.8 °C. According to studies are confirmed conclusions [11-14] of the convenience of using multithreading systems for reaching better thermal comfort conditions. As is apparent from the implemented measurements and simulations even small changes in the thermal equipment layout have a significant impact on the temperatures map of the area.

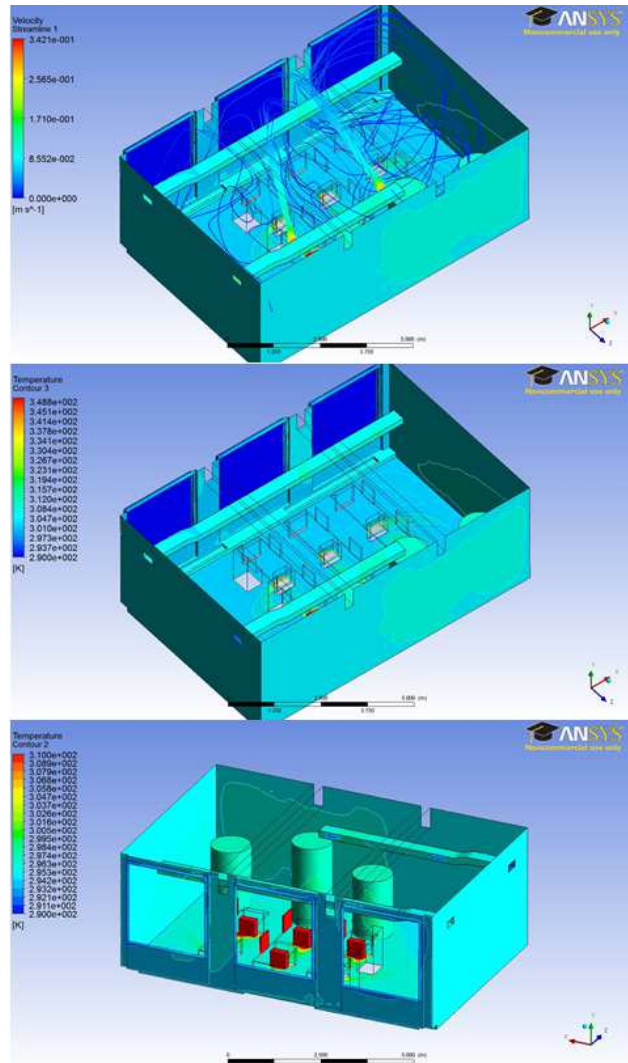


Figure 4 The results of the simulation with the disabled floor convectors

**Conclusions**

The result of the experimental measurements as well as the realized simulation confirms the possibility of heating a room only with HRV. A side effect of the above solutions is the vertical gradient of temperature layout. This layout is inappropriate, especially in its geometry, with a drop to down, which can significantly affect subjective thermal comfort. According to the results of the simulation the temperature in the lower half of the laboratory was about 2 °C lower than in the upper part of the room, where the temperature of the exhaust air was 22 °C. Heating with floor convector, shows a 60% decrease in the temperature difference, i.e. the room temperature differential felt to 0.4 °C. It also follows from the simulations that the decrease of the floor temperature reduces the circulation in the whole room, as a result of

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which the efficiency of the air exchange, which leads to its quality reduction.

**Acknowledgment**

This paper is supported by the VUKONZE - Research Centrum for Combined and Renewable Resources of Energy ITMS code: 26220220064

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**Review process**

Single-blind peer reviewed process by two reviewers.

## COMPUTED TOMOGRAPHY – ARTIFACTS CAUSED BY PATIENT

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**Keywords:** Computed Tomography, technics, artifacts, modelling

**Abstract:** One of explain what is the artifact in science and technology is artifact (error) than misleading or confusing alteration in data or observation, commonly in experimental science, resulting from flaw in technique or equipment. Artifacts can significantly interfere the quality of CT images to such an extent that they are useless for diagnosis. For the needs of optimizing image quality, it is necessary to understand why artifacts arise and how is it possible to prevent from them. In CT the notion artifact is applied on any systematic non-conformity between CT numbers in a reconstructed image and real coefficients of attenuating of scanned object. In this article we describe some artifacts caused by patient.

### 1 Artifacts of CT displaying

Artifact uses in computing (software development), means one of many kinds of tangible byproducts produced during the development of software. Exists virtual artifact, which we can describe than an object in a digital environment.

There are many reasons for CT artifacts formation. Physical artifacts come from physical process involved in acquisition of CT data. Artifacts caused by patient are induced by moving of patient or by the presence of metal objects on patient. Artifacts caused by scanner are the consequence of imperfection in scanner function. Artifacts of spiral and multi-slice technique are caused by the display reconstruction process. Construction elements incorporated into existing CT scanners minimize such artifacts which can sometimes be partly corrected by the software of scanner.

In spite of this in many cases careful positioning of patient and optimal parameter selection of scanning are the most significant factors to prevent from CT artifacts. CT image in its nature is more prone to artifacts than conventional X-ray image, because the image is reconstructed of millions of independent detector measurements. The reconstruction technique assumes that all the measurements are correct so any defective measurements are normally reflected as an error in reconstructed image [1,2].

### 2 Artifacts caused by patient

#### 2.1 Metal artifacts

The presence of metal objects in scanned area can cause strong striped artifacts. The density of metal is out of normal extent of the computer so that partial profiles of weakness are obtained. Additional artifacts as a result of beam hardening, partial volume and aliasing are a serious problem when scanning very dense objects.

*Prevent metal artifacts service.* Before scanning patients are asked to remove all removable metal objects such as jewels. It is possible to avoid unremovable objects such as dental fillings, prosthetic devices and surgical clips by lean of gantry so that metal parts do not interfere scanned part of the body. If impossible to modify required scanned part in order to avoid metal objects, the technical change mainly increasing in kilovolts can help the beam to penetrate through some objects more efficiently. The ratio of artifact partial volume is reduced by using of thinner cuts.

*Software correction of metal artifacts.* The striping caused by exceeding extent can be largely reduced by using of special software. Producers use various interpolating techniques due to replacing figures of excessive extent in profiles of weakness. Effectiveness of one of these techniques is viewed in Figure 1. However, the usefulness of the cutdown metal artifact software is sometimes restricted because although striped artifacts are removed from metal implants there is a loss of details around interface metal – tissue what is often the area of diagnosis interest. The software for correction of beam hardening should be used when scanning metal objects to minimize additional artifacts as a result of beam hardening [3].

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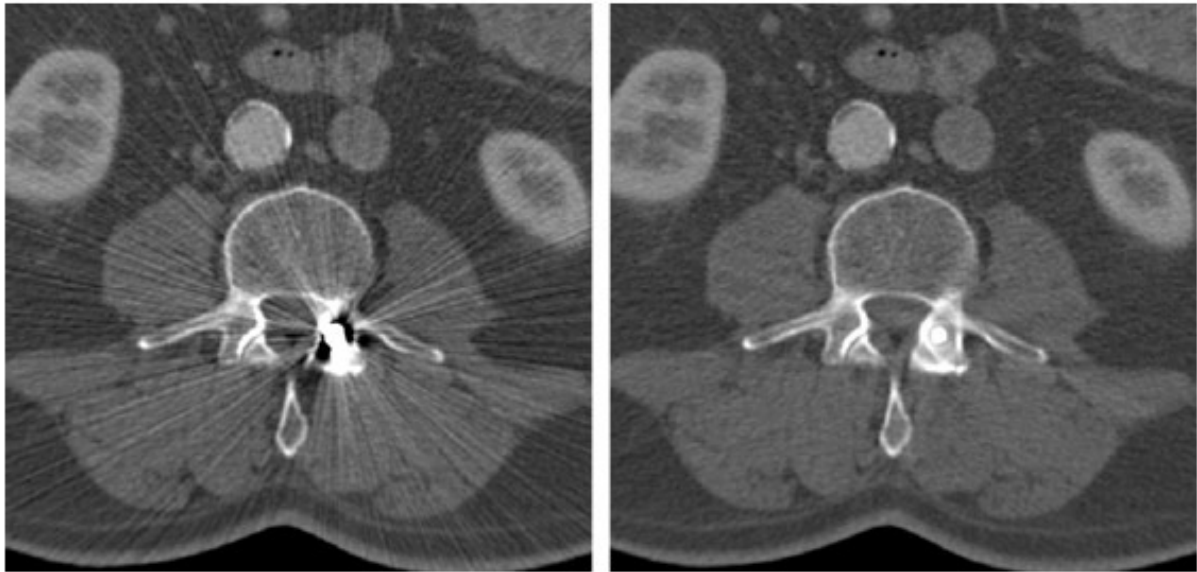


Figure 1 CT images of patient with metal implants in spine. Left displaying without correction and right with metal artifact cutdown [4].

**2.2 Patient's moving**

Patient's moving can cause artifacts of wrong registration which eventually occur as shades or stripes in displayed image (Figure 2).



Figure 2 CT image of head showing moving artifacts [2].

Steps can be carried out to prevent from free movement though during scanning it is sometimes impossible to avoid free movement. However additional devices exist for some scanners designed in order to minimize these artifacts.

Prevent moving artifacts service. Using positioning device is adequate to prevent from unwanted moving in most patients. In spite of this in some cases (e.g. children) it is inevitable to immobilize patients via sedation. Using the



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shortest scan time helps minimize these artifacts when scanning the area prone to move. It is possible to minimize respiratory movement if patient is able to hold breath while scanning. Sensitivity of image on moving artifacts depends on moving orientation. That's why it is better if starting and final position of X-ray lamp is in direction with primary movement, e.g. vertical above or under the patient when scanning thorax. Special mode of body scanning unlike head scanning mode can automatically have added a reduction of moving artifacts in displaying.

*Built-in functions for minimizing of moving artifacts.* Producers minimize moving artifacts by using of excessive and partial scanning mode, software correction and cardiac gating (see below).

*Excessive and partial scanning mode:* Maximum discrepancies in detector measurements occur between projections obtained in starting and final 360° scan.

Some types of scanners use excessive scanning mode for axial scans where 10% is added to standard 360° scan. Repeated projections are averaged what helps cutdown moving artifacts. Using partial scanning mode is also available for cutdown moving artifacts though it can result in a weaker distinction.

*Software correction:* Most scanners when body scanning automatically apply reduced balancing in starting and final projection in order to inhibit their contribution to the final image. However, it can result in increasing of rustle in final image in vertical direction depending on patient's shape.

Some scanners have also special moving correction. The efficiency of one of these methods which correct artifacts as a result of moving on the interface of liquid is viewed in Figure 3.

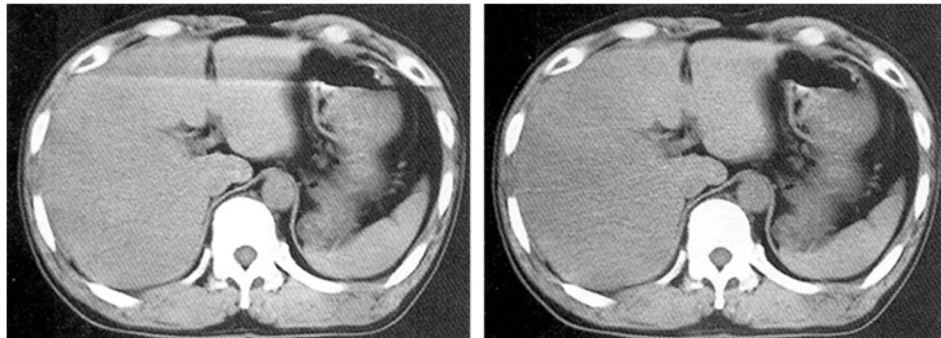


Figure 3 CT images of body with moving correction. Left made with conventional displaying and right with moving artifact correction [5].

*Cardial gating:* Fast heart movements can result in characteristic artifacts in heart images and these artifacts can imitate a disorder in outlying structures, e.g. aortic dissection. In order to eliminate these problems new techniques were developed which use data only from a part of heart action to create images. It is achieved by combination of electrocardiographic gating techniques with special methods of image displaying [3].

**2.3 Partial projections**

If a part of patient's body lies out of scanned field of view the computer has partial information about this part and striped and shade artifacts occur. This is viewed in Figure 4 which shows a patient scanned with upper limbs placed along the body instead of raising them out of scanning extent. If upper limbs are placed out of scanned field of view they are not present in the image but their presence in some projection when scanning leads to such serious artifacts in the image that significantly degrade their using. Similar effects can be evoked by dense objects such as intravenous tube containing contrast medium lying

out of scanned field. Blocking reference canals on the side of beam detectors can also interfere with normalization of data and cause striped artifacts [2].



Figure 4 CT image with striped artifacts. CT image of body of patient with upper limbs along the body but out of scanned area what causes striped artifacts (Radiology Department).



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In order to prevent from artifacts due to partial projections it is inevitable to position patient so that any part of the body does not lie out of the scanned field. Scanners designed for planning radiation therapy have larger holes and larger scanned field and they allow greater extent in patient positioning. It also allows to scan extremely enormous patients who cannot fit in the hole of normal scanners. Some producers monitor reference data canals to obtain discrepancies and if these reference data seem to be suspicious they avoid using them [2].

**Conclusion**

In medical viewing artifacts represent wrong displaying of tissue structures in medical images performed by such imaging modalities as ultrasonography, computed tomography and magnetic resonance imaging. These artifacts are caused by various phenomena such as physical effect between tissue and energy, error receiving data when patient moving or reconstruction algorithms unable to represent anatomy. It is necessary to recognize these artifacts, which can cover or pretend pathological image. For correct interpretation of diagnostic images, it is inevitable to understand the principle of particular diagnostic methods and the principle of formation of their artifacts [6]. This summary is a continuation of articles about mentioned artifacts in ultrasonography [7] and magnetic resonance [8,9].

**Acknowledgement**

This article was supported by the state grant KEGA 069TUKE-4/2017 of the Ministry of Education of the Slovak Republic.

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**Review process**

Single-blind peer reviewed process by two reviewers.